Eradication of Black Rats *Rattus rattus* L. from Bowen Island, Jervis Bay NSW

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ABSTRACT

Ground baiting was carried out in an operational pest control program between 1993 and 1995 aimed at eradicating Black rats *Rattus rattus* from Bowen Island in Jervis Bay. *Rattus rattus* was abundant across most of the Island and given their propensity to prey on ground nesting sea birds, were identified as a threat to Shearwaters (*Puffinus* spp.) in the Bowen Island Management Plan 1988. Small mammal trapping and spotlighting surveys were carried out prior to baiting in 1993 to assess the non-target species at risk of poisoning. No native mammal species were captured, although 97 *R. rattus* were trapped over 353 trap nights and two were spotlighted on two survey nights. Twenty three baiting transects spaced 50 metres apart in dense vegetation were hand cut across the Island and bait stations (n=228) were placed every 50 metres along each transect. An additional 50 bait stations were placed on rock platforms for the last two of twelve baiting events. Two rodenticides were used to avoid bait shyness (Brodificoum and Bromadiolone). Chew sticks were deployed on two occasions, in 1996 and 2002, to detect *R. rattus* presence and no sign of *R. rattus* were recorded. In 2004, trapping and spotlighting surveys were carried out to determine the success of the control program and determine if native species had responded to *R. rattus* control. There was still no sign of native ground dwelling mammals. The lack of gnawing on the chew sticks supported our conclusion that *R. rattus* have been eradicated from Bowen Island.

Key words: *Rattus rattus*, Black rat, eradication, baiting program, Jervis Bay, Bowen Island, Island.

Introduction

Rattus rattus, commonly known as the Black rat, Ship rat or Roof rat is widespread throughout the world including Australia (Watts and Aslin 1981; Atkinson 1985). The species is commonly associated with disturbed environments although they will invade natural habitat (Daniel 1973; Dowding and Murphy 1994; Cox *et al*. 2004). *Rattus rattus* causes considerable damage to crops (Ahmed and Fiedler 2002; Dickman 1999) and it is recognised for it's ability to invade and occupy islands (Clark 1980; Taylor & Thomas 1993; Amarasekare 1994; Billing and Harden 2000; Garcia *et al*. 2002; Morris 2002; Donland 2003). An overview of the role of *R. rattus* on island ecosystems can be found in Vietch and Clout (2002). Successful *R. rattus* eradications are described at the website http://www.islandconservation.org and in Howald *et al*. (2007). The critical factors affecting the colonization of islands by *R. rattus* are essential management information when designing control programs. Russell and Clout (2004) describe some of the natural and anthropological features of islands that are vulnerable to *R. rattus* invasion, and Palmer and Pons (2001) evaluate the vegetative characteristics of "rat-free" and "rat-infested" islands.

Studies have shown that *R. rattus* is an opportunist-generalists in it's foraging behaviour (Daniel 1973). Harrison (1962), Watts (1977) and Best (1969) recorded a predominance of seeds, fruit and insects in *R. rattus* diet overseas, while Watts and Braithwaite (1978) found that fungi were favoured food items in Australia. On Macquarie Island, *R. rattus* were reported to forage and impact on the mega-herb *Pleurophyllum hookeri*, causing a negative effect on the species (Shaw *et al.* 2005). *Rattus rattus* are also known to eat animal material. Watts and Braithwaite (1978) recorded a high percentage of bird feathers and flesh in the diet of *R. rattus* in Australia. These findings have been supported in New Zealand studies (see Dingwell *et al*. 1978), in nest predation experiments (Major and Gowing 1994) and on Islands (Thibault *et al*. 2002). *Rattus rattus* have been implicated in the demise of several birds species from islands around the world (Atkinson 1973; Bell 1978; Ebenhard 1988; Campbell 1991; McChesney and Tershy 1998; Billings and Harden 2000; Martin *et al.* 2000; Thibault *et al*. 2002;), reptiles (Daltry *et al*. 2001) and invertebrates (Ramsay 1978; Palmer and Pons 1996). The species has been implicated in the demise of the Christmas Island Shrew *Crocidura attenuata trichura* (Meek 2000) and two large rats (*R. nativitatus and R. macleari*) on Christmas Island in the Indian Ocean (Andrews 1909; Pickering and Norris 1996). Empirical evidence of biological impacts of *R. rattus* on Australian wildlife populations are less known.

Control of *R. rattus* on Australian islands has been attempted with varying levels of success on Coringa Islet in the Coral Sea (Mark Hallam pers. comm 1993), Norfolk Island (Paul Stevens pers. comm 1993), Barrow, Middle,

Boodie, Boomerang, Pasco and North and South Double islands in Western Australia (Morris 2002) and Lord Howe Island (Bob Harden unpub. report 1990; Billings and Harden 2000). In total, eradication of *R. rattus* in Australia has occurred on over 30 offshore Western Australian Islands and between 30-50 Montebello Islands (Burbidge and Morris 2002). *R. rattus* still occupy a large number of Australian islands. *Rattus rattus* eradication programs have also been carried out on New Zealand islands for many years (Taylor and Thomas 1994; Veitch and Clout 2002).

The mode of introduction and colonisation of Bowen Island by *R. rattus* is not known although it is proposed that they were accidentally introduced during ship landings by early explorers taking refuge in Jervis Bay during the 1790's. *Rattus rattus* successfully colonised the island before the first residents settled the island in 1928 and were probably assisted by the clearing of natural vegetation, burning for feed and stock grazing in the 1950's. There is also an absence of competitors and few predators on Bowen Island. It is possible that there have been several introductions of *R. rattus* to the island in food and stock supplies transported by boat from the mainland until the island was proclaimed within the Jervis Bay National Park in 1989, where after preventative measures were put in place to manage visitation to the Island.

There are three species of Shearwaters *Puffinus* spp. in the Bowen Island environs that migrate south to breed during summer; Wedge-tailed Shearwater *P. pacificus*, Sooty Shearwater *P. griseus* and Short-tailed Shearwater *P. tenuirotris*. The island is also inhabited by the most significant northern breeding population of Little Penguins *Eudyptula minor* (Fortescue 1991). *Rattus rattus* were observed feeding in the burrows of *E. minor* and *P. pacificus* by local Rangers (Meek and Nazer 1995). Sea birds are known to have been negatively impacted on by *R. rattus* on southern Indian Ocean islands (Micol and Jouientin 2002). Bowen Island is host to a diverse array of native birds and herpetafauna. Two species, listed as threatened under the NSW *Threatened Species Conservation Act 1995*, have been recorded on the Island; the Powerful Owl *Ninox strenua* (Paul Meek pers. obs. 1993) and the Green and Golden Bell Frog *Litoria aurea* (Gary Daly pers. comm. 1994). As a result of the anthropomorphic concerns and potential impact of *R. rattus* on the seabirds and amphibians of the Island, an operational control program was started in 1993 to eradicate *R. rattus* and restore the biological integrity of the island's fauna. The program was not experimental and was planned as a component of the National Park work program, however the program did satisfy many of the criteria identified by Bomford and O'Brien (1995) for achieving eradication in pest control programs.

Materials and Methods.

Study Site

Bowen Island, named after Lieutenant Richard Bowen because of his observations of the island in 1791 aboard the transport Atlantic (Taylor 1995), is located in the mouth of Jervis Bay in New South Wales, 250 km south of Sydney and 35 km east of Nowra (Fig. 1 & 2). The Island is 51 ha and comprises predominantly *Banksia* woodland, heath and tussock shrub land overlaying Permian sandstones. The Island is managed by the Commonwealth (Parks Australia South) within Booderee National Park and is administered under a Board of Management with Wreck Bay Aboriginal Community.

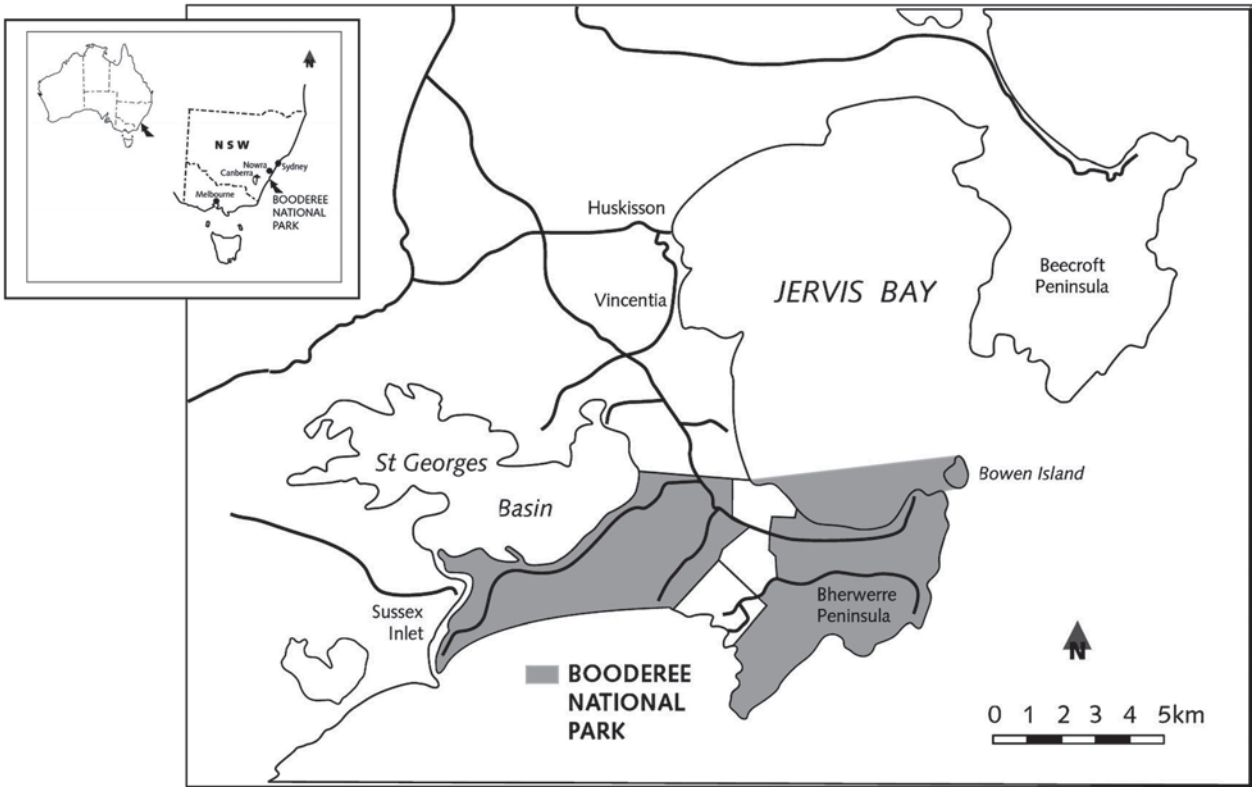

Figure 1. Location of Bowen Island in New South Wales.

Figure 2. The proximity of Bowen Island (left) to the mainland of Governor's Head in Booderee National Park, NSW (right), a distance of 302 metres. (Photo Paul Meek)

Pre-poisoning Mammal Survey 1993

A pre-control reconnaissance of the island was conducted in March 1993. Spotlighting was carried out on two consecutive nights along service tracks (~1.5 kilometres), searching and listening for native mammal species and nocturnal birds (Fig 3). Twenty five, A size, Elliott traps and four bandicoot cage traps were placed around buildings to confirm the species of *Rattus* and any potential non-target small mammals. Two surveys were carried out in April 1993, the first using 48 size A and 10 size B Elliott traps, five possum cage traps 30 x 30 x 60 cm and 10 bandicoot traps 20 x 20 x 55 cm along tracks and around derelict buildings (T1). The following week a trapping transect was slashed across the island from North to South, through all habitat types. Traps were set along this transect and on adjoining service tracks (T3) (Fig 3). Four trap types were used; size A (50) and B Elliott traps (10), bandicoot cage traps (5) and possum cage traps (10). Traps were baited with a mixture of peanut butter, rolled oats and pepperoni. Fifteen of the *R. rattus* caught were euthanased, standard body morphometrics were measured before post mortem inspection of their livers for nematodes.

Post Poisoning Mammal Survey 2004

In March 2004, 100 A size Elliott traps and 40 bandicoot cage traps were deployed along four transects in approximately the same locations as 1993 and an additional transect along a creek off Penguin Beach (Fig 3). The same bait mixture used on previous surveys was deployed. The four trapping transects covered a distance of 1585 metres. Spotlighting surveys were carried out by two observers using 50 watt spotlights over two nights along the same service tracks surveyed in 1993 (T1) plus a creek line transect off Penguin Beach (T2) for a total distance of 1575 metres.

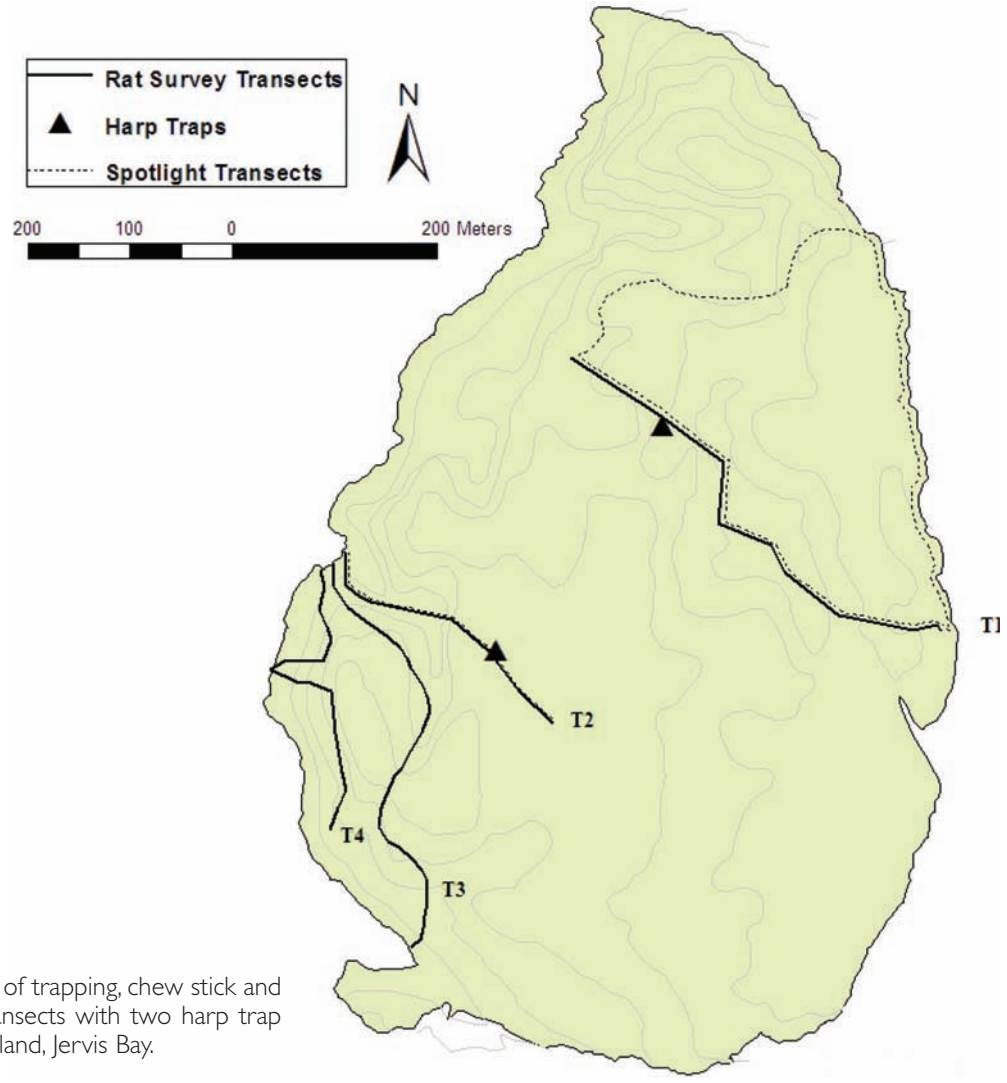

Figure 3. The location of trapping, chew stick and spotlighting survey transects with two harp trap locations on Bowen Island, Jervis Bay.

Baiting Strategy

Twenty three transects along east-west bearings were slashed manually by three teams of 3-4 people per transect from the beach to the cliff line to enable access across the island (Fig 4). Transects were spaced ~50 metres apart and the task took two weeks to conduct. The main bait stations were designed from standard "agricultural pipe" (100 mm) cut into sections (Fig 5). Stations were 40 cm long with a small (6 x 8 cm) hole cut in the top and covered by a piece of plastic. The plastic was cut from soft drink bottles and fitted snugly around the outside of the bait station, enabling field staff to see inside the station when checking baits (Fig 6). Each station was numbered, flagged and wired in place along each transect at 50 m intervals. Two hundred and twenty eight bait stations were deployed on 23 transects.

Figure 5. Agricultural pipe bait station, small holes were cut in the top to allow baiting and covered by plastic bottle sections, stations were fixed in place with "U" shaped pieces of wire. (Photo Paul Meek)

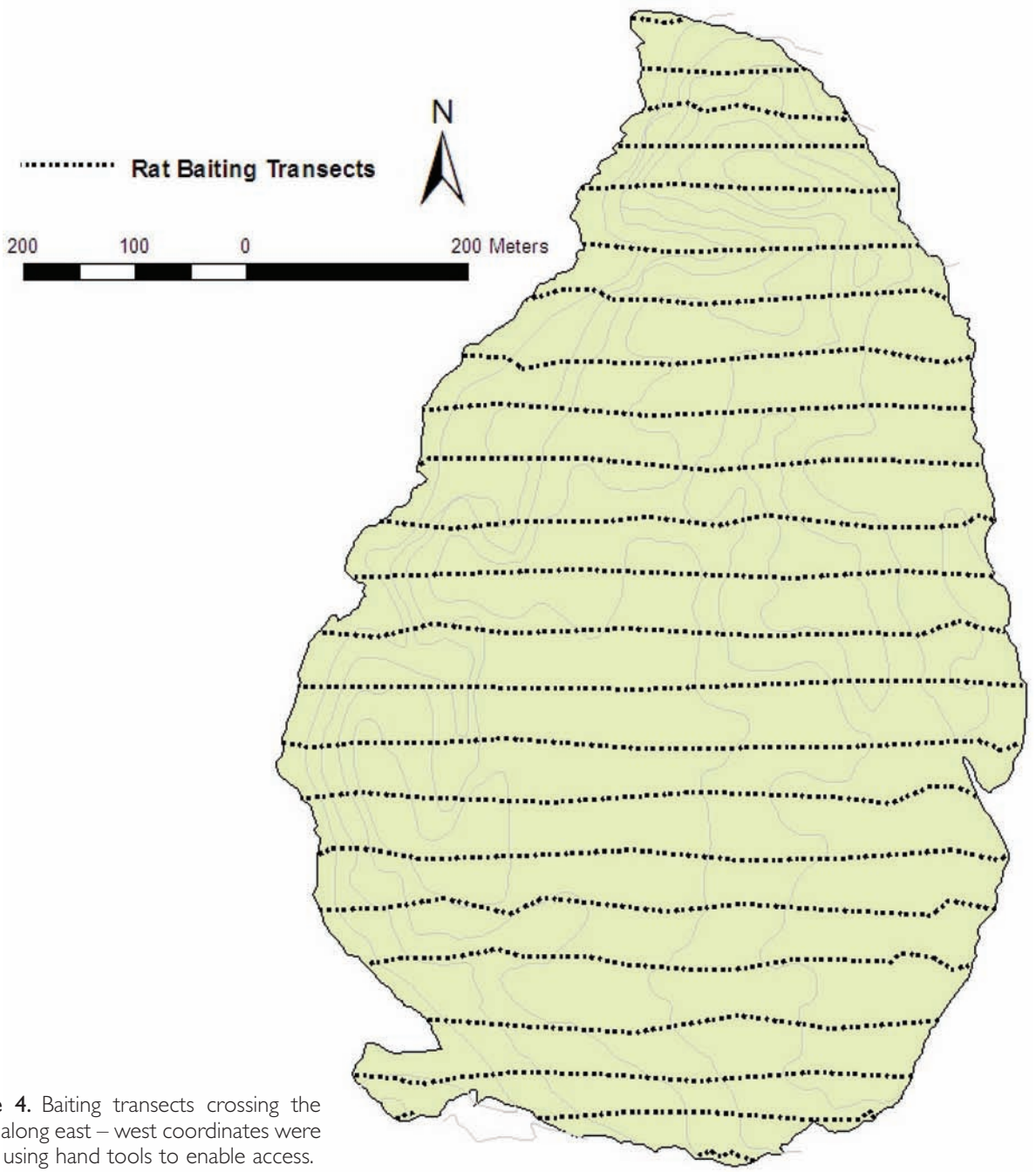

Figure 4. Baiting transects crossing the island along east – west coordinates were cut in using hand tools to enable access.

A further 50 bait stations were designed later in the program in 1994 for positioning on the rock platforms. These consisted of PVC pipe 100 mm in diameter and 20 cm long, with a 45 degree elbow and an additional 10 cm piece of pipe (Fig. 6). One end was capped and two gutter brackets were screwed to the pipe. A circular hole (63 mm) was cut in the top and covered with a piece of plastic bottle to allow access to the baits. Silicon sealant was used to glue the stations to the rock platform along the western and southern sides of the Island at the high tide mark. The poisoning program started in May 1993, 12 baiting events were carried out and final baiting occurred in December 1994.

Figure 6. Bait stations were made from PVC water pipe and gutter brackets were used for permanent placement along the waters edge on the rock platforms. (Photo Paul Meek)

Bromakill Super Rat Blocks ® (20gm) (active ingredient Bromadiolone) baits (Bait 1) were used for the first six baiting events. To overcome bait shyness during baiting events 7-12, alternate transects were baited with Bait 1 and either of two alternative baits (Bait 2&3). On the 8th and 9th baiting event, a RENTOKILL ® manufactured Bromakill bait with a special pig weaner attractant was used (Bait 2). On the 10th-12th events, a Brodificoum based bait (*Talon Wax Blocks 20 gm* ®) (Bait 3) replaced Bait 2. This pilot trial was not carried out experimentally, different bait types were merely placed on alternative transects. Four 20 gm baits were laid per bait station during each baiting event. Rock platform areas of the island were treated in March 1995 in response to a population increase. These bait stations were placed at ~30m grid spacing depending on the extent of the rock platform and high tide mark.

Bait take was recorded during each visit (except for baiting events 11-12) and baits were replaced when eaten. Baiting was continuous throughout the program and as such, rodenticide was available until removed by *R. rattus* throughout the twelve baiting events. Baiting event frequency (days between baiting) varied in duration according to either weather conditions (preventing boat landings on the island), or due to other operational difficulties (e.g. staff availability). Baiting event 11-12 and the rock platform poisoning were not assessed for bait take due to operational and access difficulties.

Chew Stick Monitoring

In 1996 and 2002, 50 wooden (pine) stakes 4 x 4 x 60 cm in length, soaked in peanut oil and peanut paste, were randomly placed along the baiting transects on the Island and around the rock platforms to detect any presence of *R. rattus*. The chew sticks were hammered 30 cm into the soil and left in-situ for several weeks, then collected and inspected by Park staff for sign of *R. rattus* gnawing. To verify that the method worked, a further 50 chew sticks were placed in vegetation between Greenpatch and Bristol Point camping areas on the mainland. The Bush rat *R. fuscipes* and *R. rattus* were previously trapped in this area in unrelated surveys (Meek unpub. data).

Results

Pre Poisoning Mammal Surveys 1993

Three trapping surveys were conducted before baiting. Two *R. rattus* were observed on the ground and in a *Banksia* tree during the initial March 1993 spotlight reconnaissance and 21 *R. rattus* were caught over three nights in both bandicoot cage traps and Elliott traps. The average weight of female *R. rattus* was 158±46 g (n=8) and 167±61 g for males (n=7). In the second survey (April 1993), 50 *R. rattus* were trapped along transects over 175 trap nights. Four Eastern Water Skinks *Eulamprus quoyii* were caught in Elliott traps in heath on the eastern cliff line and one *E. minor* was captured in a possum cage trap. On the third survey (April 1994), 26 *R. rattus* were captured over the two nights before inclement weather prevented further surveys (98 trap nights). No native small mammal species were caught and the only evidence of medium sized mammals was a small number of macropod scats. Similar scats had previously been identified as Swamp Wallaby *Wallabia bicolor* and Red-Necked Wallaby *Macropus rufogriseus* (M. Fortescue, pers.comm. 1994). How macropods arrived on the Island is unknown and they are now absent from Bowen Island.

Baiting 1993-94

Baits were checked after two nights on the first event and 78% of baits (n=852) were taken by the rats (Figure 7). Eleven days later, on the second baiting event, *R. rattus* had removed 87% of the poison laid. Bait removal rates then continued to decrease to 36%, 24%, 5% and, on the 6th event, to 4.25% of baits taken (see Figure 7). In July 1994, following breeding, *R. rattus* re-invaded the southern and northern ends of the island, probably from the un-baited rock platforms. The population explosion was evident from the increased bait removal in the seventh (28%) and eighth baiting event (22.4%). On the ninth and tenth event, bait take began to decrease again, suggesting that the population was declining. Baits were deployed on baiting events 11 and 12 although, due to circumstances beyond our control, bait removal was not recorded.

The total number of baits replaced during each baiting event is shown in Figure 8. Comparisons between Bait 1 (Bromakill®) and the combined bait removal of Bait 2 and 3 showed no difference in bait removal by *R. rattus* between baiting events 7 and 10 (Fig 9), however since this activity was not experimental, we could not statistically analyse the data (Fig. 9). Baiting effort was maintained over a period of 20 months.

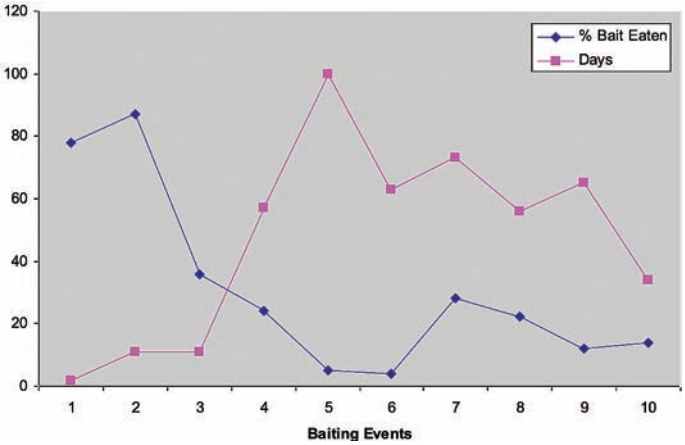

Figure 7. Percentage of poison baits taken by black rats on Bowen Island and the number of days between baiting events during 1983-4.

Chew-stick Monitoring

There were no signs of chewing or gnawing of sticks in either of the Island surveys, suggesting that *R. rattus* abundance had declined. There was evidence of gnawing by *Rattus* on the chew-sticks placed on the mainland, confirming the technique was valid. The decrease in *R. rattus* abundance is supported by Park staff observations on Bowen Island. Historically *R. rattus* persistently invaded the buildings on the Island and were seen in numerous locations across the island, however no reports had been made for many years following the baiting program. In 2008, there was still no evidence of *R. rattus* in the buildings even though food is stored in open cupboards.

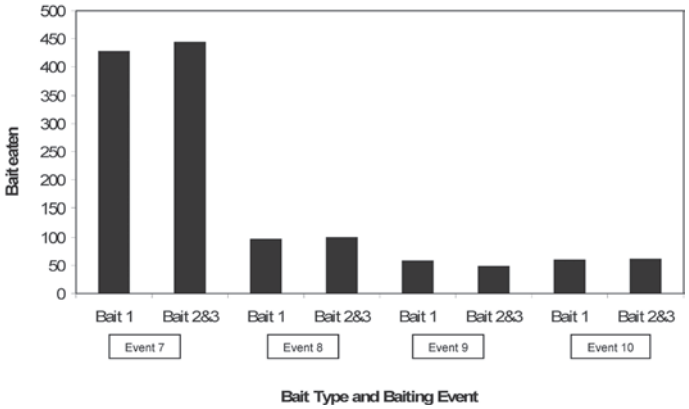

Figure 9. Comparison of bait take between Bait 1 and Bait 2 & 3 from baiting events 7 to 10.

Post Baiting Mammal Survey 2004

Small and medium sized mammals were not detected over the 560 trap nights, and only one Australian Raven *Corvus coronoides* was caught. Spotlight surveys did not detect any *R. rattus* or arboreal mammals, one shearwater was observed on spotlight transect 2 (Figure 3). *Rattus rattus* was not trapped and signs of them have not been detected over the last 14 years. There is good evidence to support the claim that *R. rattus* has been eradicated from the Island as a result of baiting.

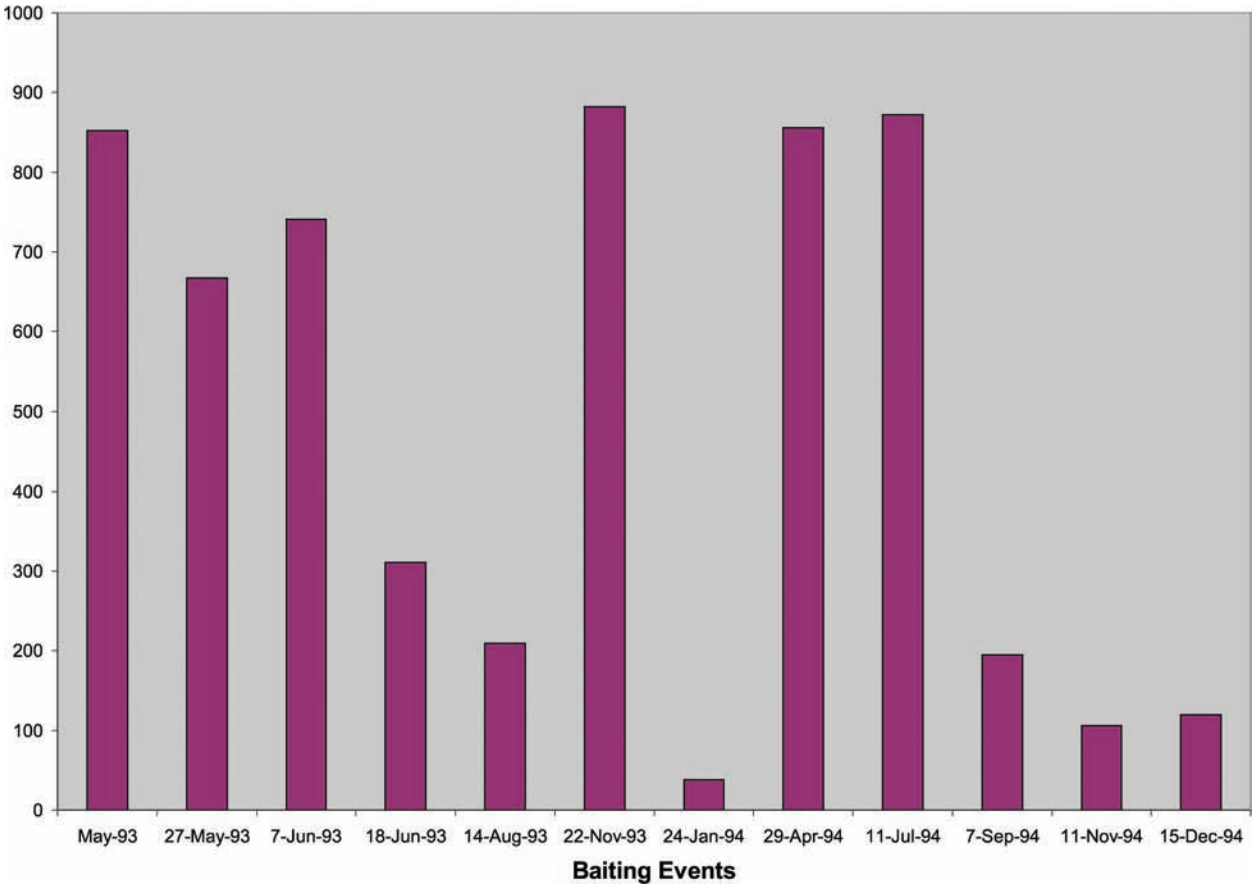

Figure 8. Total number of replacement baits deployed each baiting event. On four occasions all baits were replaced regardless of the number of baits eaten by the rats.

Discussion

Based on trapping, spotlighting, chew-stick monitoring and personal observations of Park staff over a 14 year period, we conclude that *R. rattus* has been successfully eradicated from Bowen Island. Bait removal by *R. rattus* followed a normal declining trend over time. Unfortunately, removal of bait on the last two baiting events was not recorded due to human error; the eleventh baiting was left for many months before checking and had deteriorated (melted) to such an extent that counting was impossible. The twelfth baiting and rock platform baiting was laid, but staff were unable to return and collect the data. It was not until the chew-stick monitoring was deployed as a surrogate for trapping, and the post baiting survey in 2004, that it was possible to gauge the success of baiting. The placement of the bait stations on the rock platform, although not in the original plan, wa s very important towards the end of the baiting program. *Rattus rattus* that survived in the rock platforms would have definitely re-colonised the island if not poisoned, as occurred early in the program. There were no signs of bait shyness (Singh and Saxena 1991) of Bromakill baits and given *Mus domesticus* was not present on the Island, we did not encounter the same issues as programs on Lord Howe, where *M. domesticus* became dependent on poison baits as a food source (Billings and Harden 2000).

The absence of both native arboreal and ground dwelling mammals on the Island is interesting given the close proximity of the mainland and the suitability of habitat for native species. Reptiles, birds and amphibians have managed to maintain breeding populations on Bowen Island although reptile and amphibian diversity is relatively low. It is unknown if *R. rattus* preyed on any native species on the island, although penguin carcasses were often found on the rock platform showing signs of gnawing and chewing. Dietary studies on rats indicate that they are opportunistic in their choice of food types (Daniel 1973) eating both animal (Atkinson 1978) and plant matter (Campbell 1978, Watts 1977 and Watts & Braithwaite 1978). Fruits and berries are present on the island and it is probable that *R. rattus* consumed some species. *Rattus rattus* abundance, based on trapping captures, was highest near the penguin burrows and rock platforms on the west coast, so food items such as crustaceans, regurgitated penguin food, beach flotsam and jetsam could have been important food resources.

The distribution of *R. rattus*, based on captures, appeared to be related to micro-habitat, specifically understorey vegetation and structure such as *Lomandra longifolia* (Fig. 10), a tussock blade grass and *L. longifolia* seeds may have also constituted an important part of their diet. There were no signs of *R. rattus*, based on trapping or baiting, in the dry heath located on the eastern side of the island. Amarasekare (1994) and Pye *et al*. (1999) also found that *R. rattus* in Hawaii and on Macquarie Island preferred grassy tussock understorey. Cox *et al*. (2000) proposed that leaf litter and understorey habitat was an important variable driving habitat use by *R. rattus*. In the absence of more rigorous investigations we are unable to support these findings, however captures on Bowen Island were highest in *Lomandra* habitat with a sand substrate and little or no leaf litter.

Figure 10. Two of the authors Hawksby (late) and Meek, baiting a station in *Lomandra longifolia* habitat. (Photo Parks Australia)

Observations on the reproductive status of female *R. rattus* indicated that breeding occurred between October and March. This has also been reported by Daniel (1972) in New Zealand populations. During this period, we attempted to increase the treatment frequency to have the greatest impact on the population. Between the sixth and seventh baiting events there was a considerable increase in *R. rattus* abundance as indicated by the percentage of baits taken. This occurred after a period of bad weather and dangerous boating conditions which prevented the replacement of new baits until April 1994. During these three months, the *R. rattus* was able to successfully re-invade parts of the Island. It is not known if the *R. rattus* swam from the mainland or if the rats were dispersing adults from the rock platforms, the latter is most likely. Since there has not been re-colonisation from the mainland in 14 years, it would suggest that *R. rattus* living in the rock platform habitat dispersed into the vacant niche and located poisonous baits.

Pre- and post-poisoning mammal surveys unsuccessfully detected any native or introduced ground dwelling mammal species and this combined with chew stick data confirmed that *R. rattus* has been successfully eradicated from the island.

During the final field visit in 2004, harp trapping was also carried out to produce an inventory of micro-bat species present on Bowen Island. Three *Chalinolobus morio* and four *Nyctophylus gouldii* were detected although these authors can not comment on the possible impact that *R. rattus* may have on bat species since no trapping was carried out before control. The bats were only detected in dense *Banksia integrifolia* habitat, the only habitat trees suitable for roosting on the Island. This habitat was also where *R. rattus* was seen climbing *Banksia* trees, and given their opportunistic behaviour and propensity to predate on bird nests, there is a possibility that *R. rattus* could have preyed on these microbats.

Management Implications

Bowen Island is an extremely sensitive environment. Access to the Island by the public is not permitted and this should be enforced to avoid re-introducing *R. rattus* and to minimise impact on the cultural and ecological values of the Island. Future management plans should continue to monitor the

south and western coastline of the Island to ensure that any re-introduction of *R. rattus* is contained before the population becomes viable. *Rattus rattus* is known to swim across distances of 300-400 m (Cheylan 1986 in Palmer and Pons 2001). The installation of chew sticks, hair tubes (Suckling 1978; Murray 2005), tracking tunnels (King and Edgar 1977), wax block baits or monitoring blocks (Thomas *et al.* 1999; Whisson *et al.* 2005) by the National Park service to monitor rat presence several times per year (outside penguin breeding period) is highly recommended. At the first sign of *R. rattus* presence, every attempt should be made to re-instate poison bait stations. Bowen Island provides valuable breeding habitat to *E. minor* and *Puffinus* species and the eradication of *R. rattus* has improved the ecological values of this Island. In a pest free state, Bowen Island may also provide a suitable location to breed captive mammals, e.g. Southern Brown Bandicoot *Isodoon obesulus* and Long -nosed Potoroo *Potorous tridactylus* for re-introduction into Booderee National Park as a component of the park fox control and re-introduction program. The ecological effect of an absence of ground dwelling and arboreal mammals on Bowen Island vegetation and ecosystem functions has not been investigated and with *R. rattus* eradicated, and large areas of woodland now senescing, it would be timely to consider the implications of the absence of fire and pollinating terrestrial fauna.

Acknowledgments

This paper is dedicated to Richard (Hawkeye) Hawksby – an Aboriginal man from the stolen generation - taken from his people in Brewarrina and brought up in Nowra, later to start a family at the Wreck Bay Aboriginal Community. Hawkeye died unexpectedly in 2005 and is sadly missed by us all. The project was funded by the Bureau of Resource Sciences (Bureau of Rural Sciences), Department of Environment, Sport and Territories (now Dept. of Transport and Regional Services) and the Australian Nature Conservation Agency (now Department of the Environment, Water, Heritage and the Arts). We are grateful to Glen Saunders, Martin Fortescue, David Murray, Judy Caughley and Dick Veitch for their advice and help. Thank you to the multitude of people who helped us in the field, there are far too many to mention. Greg Turner provided useful comments on the design of the 'rock platform bait station'.

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